CONSULTANT REPORT

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Public Interest Energy Research
CALIFORNIA ENERGY COMMISSION

Strategic Energy Research

DEMONSTRATION AND EVALUATION OF SOLID STATE INTERCONNECTION SYSTEM

Gray Davis, *Governor*

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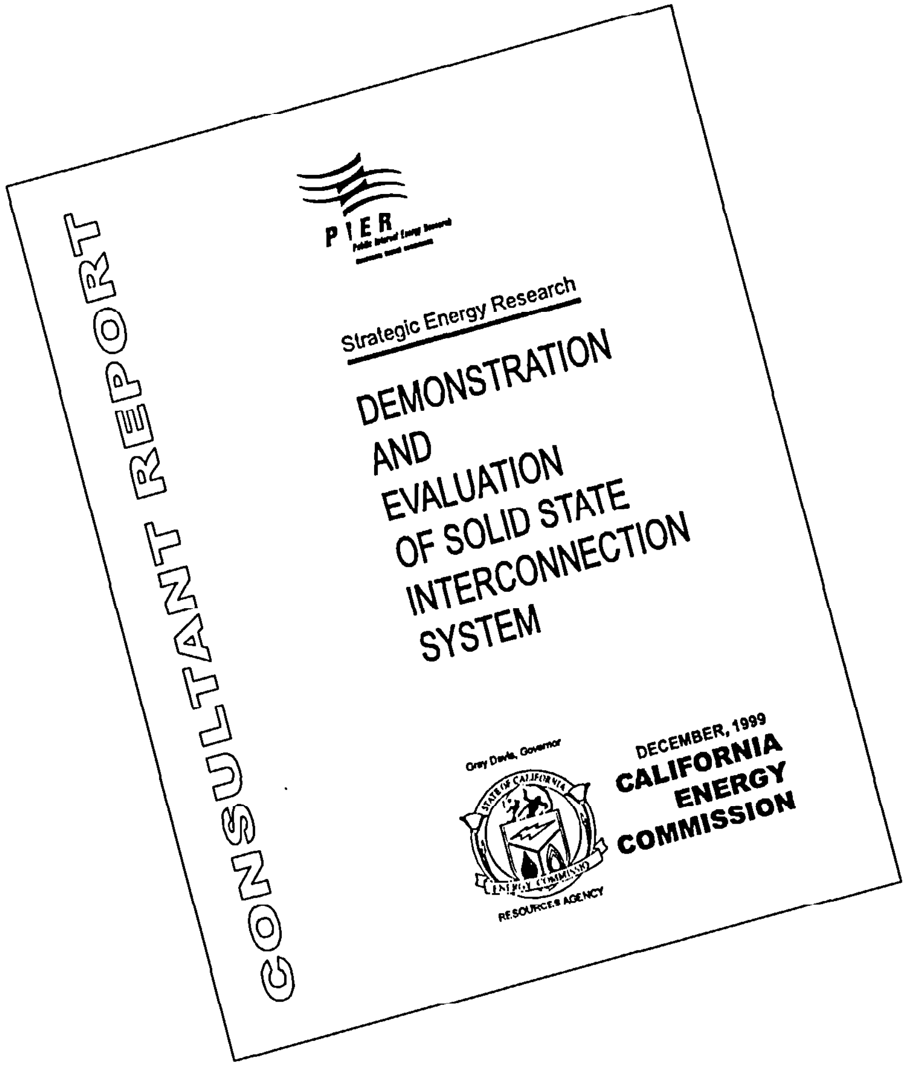

CALIFORNIA ENERGY COMMISSION

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Legal Notice

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Preface

The Public Interest Energy Research (PIER) Program supports public interest energy research and development that will help improve the quality of life in California by bringing environmentally safe, affordable, and reliable energy services and products to the marketplace.

The PIER Program, managed by the California Energy Commission (Commission), annually awards up to $62 million through the Year 2001 to conduct the most promising public interest energy research by partnering with Research, Development, and Demonstration (RD&D) organizations, including individuals, businesses, utilities, and public or private research institutions.

PIER funding efforts are focused on the following six RD&D program areas:

- Buildings End-Use Energy Efficiency
- Industrial/Agricultural/Water End-Use Energy Efficiency
- Renewable Energy
- Environmentally-Preferred Advanced Generation
- Energy-Related Environmental Research
- Strategic Energy Research.

In 1998, the Commission awarded approximately $17 million to 39 separate transition RD&D projects covering the five PIER program areas. These projects were selected to preserve the benefits of the most promising ongoing public interest RD&D efforts conducted by investor-owned utilities prior to the onset of the electric utility restructuring.

What follows is the final report for the Demonstration and Evaluation of Solid-State Interconnection System project, one of six projects conducted by San Diego Gas & Electric. This project contributes to the Strategic Energy Research program.

For more information on the PIER Program, please visit the Commission's Web site at: http://www.energy.ca.gov/research/index.html or contact the Commission's Publications Unit at 916-654-5200.

Executive Summary

Purpose

The purpose of this project was to demonstrate technology that would reduce the cost of parallel interconnection to electric distribution grids from distributed generation systems while still maintaining mandated safety and system protection features.

Technologies under consideration included solid-state interconnection devices and advanced generation systems such as new dual-fuel (90 percent natural gas, 10 percent diesel) reciprocating engines, advanced gas turbines, and microturbines.

Anticipated benefits from distributed resources and generation included:

- Improved electric system reliability and integrity at a minimum cost by integrating generation resources in a local area
- Reduced requirements for new distribution and transmission facilities.

Objectives

- Demonstrate a solid-state interconnection device with remote dispatching and control capabilities
- Demonstrate an advanced dual-fuel generator (90 percent natural gas and 10 percent diesel)
- Demonstrate other advanced generation systems

Outcomes

- Solid-state interconnection device connected to an electric utility distribution grid was successfully implemented and demonstrated.
- Dual-fuel system was not permitable because of emission constraints.
- Other advance generation technology was not available in time to meet project schedule.

Conclusions

- Solid-state interconnection device can safely interconnect in parallel to electric grid.
- Solid-state interconnection device is relatively the same size and has the same ease of operation with a wide range of generator sizes.
- Solid-state technology shows promise for reducing cost of interconnection.
- The dual-fuel generator originally proposed would not be cost effective as a distribution-generation option because of emission control costs in California.
- Other advanced generation technologies (such as microturbines and advanced gas turbines) showed promised but were not ready in time to meet the schedule for this demonstration.

Recommendations

- Demonstrate the solid-state interconnection device with automatic transfer switch and test under live power outage condition.

- Look at alternative suppliers of solid-state interconnection devices to provide competition to reduce cost and improve quality of product and services.
- Demonstrate the incorporation of advance generation systems with the solid-state device when such systems become available.

Abstract

Interconnection of distributed energy resources to the electric utility grid has been a subject that continues to create controversy because of cost and system protection requirements. California Public Utilities Commission Electric Rule 21, established in 1980, addresses the interconnection and protection requirements of power generation systems connected to electric grids. This Rule, enacted when PURPA (Public Utility Regulatory Policies Act) regulated qualified facilities, has not been revised to consider new interconnection technology.

The use of solid-state technology for meeting Rule 21 interconnection requirements to electric utility grids may potentially facilitate the rapid deployment of distributed energy resources in California. Performance issues to verify include protection and safety performance, system cost compared to conventional technology, and acceptance of the solid-state technology by utility protection engineers and operations personnel.

This project successfully demonstrated a state-of-the-art, solid-state system protection device that meets Rule 21 requirements. This, and other like devices, use power electronics to monitor and protect the generation system as well as provide safety by automatically disconnecting from the electric utility grid when necessary.

1.0 Introduction

The purpose of this project was to demonstrate technology that would reduce the cost of parallel interconnection to electric distribution grids from a distributed generation system while still maintaining mandated safety and system protection features.

Technologies considered for this demonstration included:

- An advanced solid-state grid interconnection system with remote dispatching and control capability. These capabilities are essential for streamlining the integration of distributed resources into the existing electric distribution system.
- An advanced dual-fuel generation system was also evaluated but proved inappropriate because of high emission control costs.
- Other advanced generation systems were not available at the time this project was conducted. Manufacturers are currently testing systems such as low emission reciprocating engines and advanced combustion turbines. Commercial availability is anticipated in late 1999 or early 2000. These systems include microturbine generators, combustion turbines from the US Department of Energy's (DOE) advanced turbine system (ATS) program, and private efforts by engine manufacturers.

Anticipated benefits from distributed resources and generation include improved electric system reliability and integrity. Cost would be kept to a minimum by integrating generation resources in an area near the load center. This could also reduce the need for new distribution and transmission facilities

1.1 Project Objectives

The project had three major objectives:

- Demonstrate a solid-state interconnection device with remote dispatching and control capabilities
- Demonstrate an advanced dual-fuel generator (90 percent natural gas and 10 percent diesel)
- Demonstrate other advanced generation systems.

1.2 Project Approach

To accomplish these objectives, we determined that the following activities would need to be performed.

- Research and select candidate technologies by:
  - Participating in the Electric Power Research Institute (EPRI) Distributed Energy Resource Target for 1998
  - Attending related symposia and trade shows.
- Coordinate with technology suppliers for possible collaboration with SDG&E to reduce demonstration costs.
- Obtain all necessary environmental permits.

- Coordinate with SDG&E distribution planning group to determine host site for demonstration.
- Coordinate with SDG&E Distribution Standards Group and System Protection Engineering to determine requirements for connecting the demonstration system to a 12 kV distribution circuit.
- Test generation technology and interconnection system to evaluate their operating characteristics during periods of transient behavior.
- Procure necessary equipment such as a step-up transformer and related gear to interconnect a generation system to the electric distribution grid.

1.3 Report Organization

The body of this report is divided into two sections. The Discussion Section (2.0) delineates the technology selection process; testing requirements, procedures, and results; and the economic benefits identified. Conclusions and recommendations derived from the project are presented in Section 3.0.

2.0 Discussion

2.1 Technology Selection

Identifying the appropriate solid-state interconnection system involved two phases:

- Acquire information on available technology by participating in symposia and trade shows.
- Select system.

2.1.1 EPRI and Technology Symposia Activity

During 1998 SDG&E participated in EPRI's Distributed Resource Target technology symposia and trade shows to identify the state-of-the-art of distributed resource generation and solid state interconnection technologies. EPRI experts and technology suppliers presented development status on distributed energy resource generation technology.

SDG&E participated in quarterly EPRI advisory meetings that provided direction on distributed energy resource activities in the 1998 and 1999 plan. Other activities included SDG&E participation in EPRI Distributed Energy Resource Week, California Alliance for Distributed Energy Resources (CADER), and PowerGen conferences.

EPRI reported on the status of their development program on generation technology for distributed resource applications and a related project modeling system dynamics on an electric distribution circuit with several distributed energy resource technologies interconnected to that circuit. An update on that project will be presented at the next in EPRI Distributed Energy Resource Week program in 1999. One presentation at a technology conference introduced power electronics to provide protection relays to distributed energy resource technology when operated in parallel with an electric utility grid.

Based on the literature and discussions with representatives, we determined that the Encorp, Inc. solid-state interconnection device would provide the needed flexibility because of its local and remote control capabilities. We identified the Encorp solid-state interconnection system as the demonstration system for this project. In July 1999 SDG&E negotiated with Encorp to provide the solid state interconnection device to SDG&E by September 1, 1999 for integration with a 1600 kW diesel generator set. The Encorp device was mounted on a step-up trailer that would be used to interconnect the generator to the electric grid.

SDG&E successfully negotiated a contract with EPRI to provide tailored collaboration funds to purchase a portion of the equipment required for the demonstration.

2.1.2 Solid-State Interconnection System

The remote monitoring, start-up, and stopping capabilities of the Encorp solid-state interconnection device (Figure 1) provided a unique system for control of the generator set and protection of the electric distribution system. The generator and relay protection of the electric distribution and generator systems can be monitored through a laptop computer using a telephone line.

Figure 1. Encorp Solid-State Utility Grid Interconnection & Generator Control Device

The main components of the Encorp interconnection system are a Cutler Hammer 3000 Amp circuit breaker, D500 Display, and Encorp Generator Power Control / Power Transfer Control (GPC / PTC). The components are housed in a NEMA 3R cabinet, which is designed for outdoor use. The GPC unit contains the equivalent of a SEL 351 protective relay system (51VR, 81 o/u, 59, 27, 50, 32, and 46) These relays provide protection for under and over voltage, current, and phase angle. See Appendix II.

The GPC remotely controls generator output and monitors several operating parameters such as generator speed in revolutions per minute, temperature, pressure, voltage, current, frequency, VARs (reactive power), and power. It uses a software-based auto-synchronization device for paralleling the generator to the utility grid.

The Encorp generator system has been used in applications with smaller generation systems than the one anticipated for this project. Integrating the Encorp device and a generator system larger than 1000 kW was part of the demonstration to evaluate the flexibility of the solid-state device in providing adequate relay protection and remote system operation in a utility application.

The solid-state device was delivered to SDG&E for preliminary testing by our protection engineers. It was returned to Encorp for installation in the Nema, 3R cabinet with a 3000-Amp breaker prior to delivery of the complete device to SDG&E in September 1999.

The solid-state interconnection device was incorporated into a step-up trailer with a step-up transformer, grounding bank, and switch. The Encorp unit monitored and controlled the generator and monitored the utility grid for voltage and current. The output from the power generator is passed through the 3000 Amp switch in the Encorp unit and is connected to the electric distribution grid via the step-up transformer.

2.1.2.1 Step-Up Trailer

To make the system portable, the solid-state interconnection device was incorporated into a step-up trailer. The trailer contains a 480V / 12kV, 1500kVA transformer, 300kVA grounding bank, and 12kV, 600Amp, PME3 switch (Figure 2). The Encorp system was fitted with a Cam-lock connector box for the 27 cable connections between the generator and the trailer. This number of connections is required for the size of cable at this voltage rating.

Figure 2. Step-Up Trailer

2.1.3 Generation Selection

It was decided that an advanced generator system for the prime mover would be an interesting augmentation to this demonstration. A stationary dual fuel system (90 percent natural gas, 10 percent diesel) was considered, but it was later eliminated because of excessive emission levels from its diesel fuel operation.

We then investigated using another advanced generation system.

Solar Turbines and Allison Turbines indicated that their ATS-type turbine products would meet the ATS program goals of less than 9 ppm on NOx and a thermal efficiency of at least 40 percent. However, this technology was still in the testing stage and was not available in time for this project. No other advanced generation systems were available.

2.1.3.1 Dual-fuel Generator

Initially a 3000 kW Caterpillar dual-fuel (90 percent natural gas and 10 percent diesel) generator that would operate at a SDG&E substation was considered as a prime mover for this project.

San Diego Air Pollution Control District required nearly 200 tons per year of NOx offsets in order to obtain a permit to operate the system. Or the system would have to be equipped with an after process control technology to reduce airborne emissions to compliance with environmental regulations. At issue was the 10 percent diesel burn by the engine, which accounted for nearly 80 percent of system emissions.

Hawthorne Power Systems (HPS) investigated an alternative for emissions cleaning at the exhaust. The alternative solution was estimated to cost $500,000. . The dual-fuel generation system was dropped from the project.

2.1.3.2 Advanced Generation Alternatives

A generation technology alternative was a DOE ATS program product. But no ATS product was anticipated until mid to late 1999.

Another alternative power generator system was a low emission system currently being demonstrated by the Catalytica Company at its facility near San Jose, California. Catalytica is working on a catalytic combustor technology for combustion turbines that would achieve less than 5ppm NOx from a 1,500 kW combustion turbine.

In late June 1999 it was clear that neither the ATS nor Catalytica technologies would be available within the time constraints of this project. This issue was discussed with the California Energy Commission’s project manager and a decision was made to continue with the demonstration of the solid-state system using conventional generation technology as the prime mover. Consequently, the focus of this project shifted to the solid-state interconnection device’s operation and performance with a readily available generator regardless of type.

2.1.3.3 Generator Selected

A HPS 1600 kW diesel generator was chosen as the generator for this project. The Caterpillar diesel generator is a 2300 HP, 480V, 1,600kW unit housed in a mobile trailer including a 1250 gallon fuel tank. Environmental permits for this system were supplied by HPS as part of a three-month lease agreement.

2.2 Environmental Permits

SDG&E personnel coordinated with regulatory and environmental agencies to ensure that permits were obtained in a timely manner and without unnecessary burden to the project.

Permits for the generation system were obtained by HPS.

2.3 System Test

The Encorp system was bench tested by a SDG&E relay technician to ensure that the electronic relays operated according to utility standards. The Encorp system was delivered directly to HPS's facilities for installation on the step-up trailer. Once the step-up trailer was completed, the trailer and the HPS 1,600 kW generator were delivered to SDG&E for initial testing as an integrated unit, using a load bank prior to an on-line test, at a SDG&E facility. SDG&E coordinated this test with personnel from Encorp and HPS

The test criteria in the field for the Encorp system included the verification of generator control under transient and steady state conditions and the Encorp system's reaction during a loss of load condition.

Operations tested included:

- Remote dispatching of the generator system
- Diagnostic data and alarms for generator and utility system
- Operation data from generator and utility power line
- Response time to disconnect in case of circuit and load fault
- Response time to full-load
- Effectiveness of synchronization with utility circuit
- Ease of use by operators

The generator and step-up trailer were transported to SDG&E's Metro service yard to complete Encorp system configuration and operator training. Encorp personnel met with SDG&E engineers to ensure that the protection relay settings met Rule 21 for interconnection to the distribution system. The integral communication system was also configured to ensure that system could be monitored and controlled remotely.

The generator set was connected to a 12 kV circuit through the primary side of a distribution transformer within the SDG&E facility (Figure 3). The system was operated for about six to eight hours a day for a total of 240 hours. Both a laptop and desktop computers, equipped with the Encore software successfully dispatched the system.

Figure 3. Step-Up and Generator Trailers Connected to a Distribution Circuit

At the Metro facility an electrical switching order was sequentially initiated to close the pole switches. After verification of the SR (service restorer) settings, these switches were closed, energizing the cable up to the open trailer mounted PME-3 switch.

The HPS 1600 kW genset was started from the Encorp controller and energized the 480V cable up to the incoming side of the Encorp circuit breaker. Then the PME-3 switch was closed energizing from utility side of the Encorp breaker.

SDG&E engineers installed a Reliable Power Meter unit to the power cables connecting the step-up trailer to the distribution transformer to measure the power quality delivered to the distribution system. The voltage, current, and harmonics were measured and monitored at the sample rate of 128 samples per second to determine if the solid state interconnection device would affect the quality of power output.

A typical day of power quality data showed no fluctuation on voltage or current. This data demonstrated that the power delivered across the solid state interconnection device was well within the power quality limits required by SDG&E. The only voltage spikes observed were due to the stop and start conditions of the generator (Figure 4). All were within the fluctuation limits of SDG&E and there was no perceptible voltage fluctuations or harmonic generation.

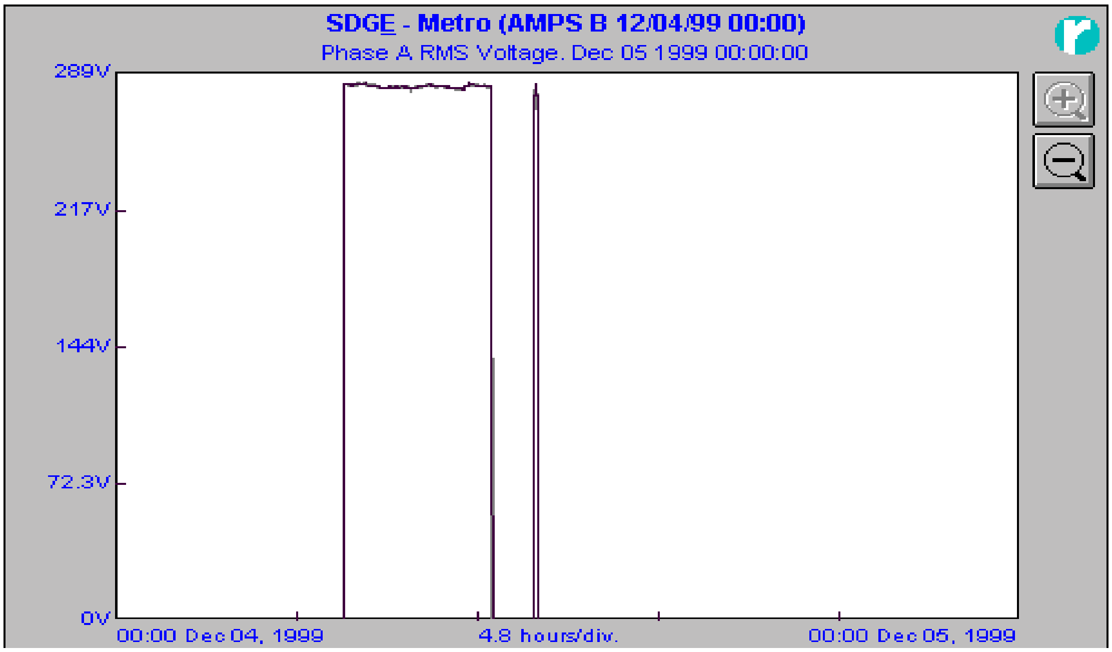

Figure 4. Power Quality Data

Although no system outage was experienced during the period of operation, there was no indication that the Encorp system would not perform as expected. It would either disconnect the generator from the grid or remain as a stand-by generator to supply power to the distribution circuit.

The Encorp device was able to ramp up the generator output at 100 kW increments by a push of a button. However, for remote operation the push button action could be cumbersome. A dial up option should be provided.

The generator set was locally controlled from a small solid-state panel in front of the Nema cabinet. The cabinet housed a disconnect switch and the Encorp device (Figure 1). A series of three push buttons starts the generator and automatically synchronizes it to the electric utility distribution grid.

The ease of operation and the portability of the system demonstrated in this project could be of benefit to distribution utilities as a tool to optimize system operations.

At the conclusion of the tests at the Metro facility, the step-up trailer and generator-set were moved to another SDG&E facility where a cellular telephone capability was added to create a transportable generator system for further demonstration at other locations within the SDG&E distribution system.

Our experience with the Encorp device was very positive. Although some issues with system integration, set-up, and configuration arose, this was expected during a demonstration project. SDG&E will continue to work with Encorp to provide feedback on system operation and suggestions on how to improve service, functionality, and ease of integration.

2.4 Benefits to California

Traditionally the cost of interconnection technology to operate power generation systems in parallel with the electric distribution grid has been high. This has often made cogeneration and distributed energy resource projects uneconomical. For small size distributed generation projects, this cost places an economic burden making the project uneconomical to implement.

A goal of this demonstration was to evaluate the economic benefit to distributed energy resource technology from solid-state protection systems that would be used as interconnection devices for parallel operation with a utility grid.

The costs of the solid-state interconnection device and required system components, such as software and telephone access, were carefully monitored to ensure a fair and equitable comparison with conventional technology. The solid-state system cost nearly $70,000 with an additional $5,000 allocated for training and step-up trailer modifications. The cost of the step-up trailer including equipment was nearly $90,000.

Conventional equipment generally costs in the range of $50 to $100 per kW. The estimated cost of conventional interconnection equipment for a 1600 kW generator would range from $80,000 to $160,000. If the solid state cost basis is $75,000, the cost benefit ratio would range from 1.06 to 2.13.

An advantage of solid state interconnection devices over conventional protection relay equipment is that it could be used for a wide range of generator sizes using the same footprint. The cost of solid state systems is expected to come down as competition increases with additional suppliers of similar systems.

Greater acceptance of solid-state interconnection technology by utility protection engineers and lower costs would ease deployment of distributed energy resources in California. Pending results of distribution system dynamics and environmental impact evaluations, distributed energy resources may defer or replace the need for new distribution and transmission lines.

2.5 Outcomes

Operating the solid-state interconnection device system in conjunction with a standard diesel generator, SDG&E successfully demonstrated its viability

The cost of the Encorp device compared to conventional interconnection equipment needs to improve to achieve a more uniform cost to benefit ratio for generation technologies in a wide range of capacity from a few tens of kilowatts to hundreds of kilowatts. If this is accomplished through volume sales and improved production, solid-state protection devices will ease the deployment of distributed resources.

The operator training was held over two-half day periods. The training included familiarization of the Encorp device, relay settings, remote communication, and operation of the generator set. System set-up and operating instructions are included as Appendix I.

3.0 Conclusions and Recommendations

The demonstration and evaluation of solid-state interconnection system resulted in the following conclusions and recommendations.

Conclusions

- Solid-state interconnection devices can safely interconnect in parallel to an electric grid.
- Solid-state interconnection devices are relatively the same size and have the same ease of operation with a wide range of generator sizes.
- Solid-state technology shows promise for reducing cost of interconnection.
- Dual-fuel generator originally proposed would not be cost effective as a distribution-generation option because of cost of emission control in California.
- Some other technologies showed promised but were not ready for demonstration.

Recommendations

- Retrofit the solid-state interconnection device with automatic transfer switch and test under live power outage condition.
- Look at alternative suppliers to promote competition to reduce cost and improve quality of product and services.
- Demonstrate advance generation system incorporated with the solid-state device when such systems become available.

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Appendix I

SET-UP AND OPERATION INSTRUCTIONS FOR ENCORP SOLID STATE DEVICE

APPENDIX II

*EN*POWER-GPC PRODUCT DATASHEET

APPENDIX III

SS INTERCONNECTION / GENERATOR TEST AT METRO C&O CENTER

APPENDIX IV

SDG&E STANDARD PRACTICE
MOBILE STEP-UP TRAIL

Appendix I

Set-Up and Operation Instructions for Encorp Solid State Device

SET-UP

<u>CAUTION:</u> The Encorp SOLID STATE Device and Step-Up Trailer can only be used with it's designated Generator. Due to the Encorp system protocol for generator control, any other generator will cause operational problems with generator control.

STEP-UP TRAILER

- ❑ Check OPEN the PME-3 Switch.
- ❑ Connect the two trailer ground leads to the distribution system ground.
- ❑ Connect the 480v cables to both the generator Cam-Lock panel and the Step-Up Trailer Cam-Lock panel. [6 neutral cables, 1 common ground cable, 21 secondary power cables (7 each phase)]
- ❑ Connect the two Multi-pair Power Control cables between the generator Cam-Lock panel and the Step-Up Trailer Cam-Lock panel.
- ❑ Install the three primary cables, on Stand-offs, in the PME-3 Switch. Connect the concentric neutrals to the unit ground.
- ❑ Position the three primary cable at the structure where the parallel is to be made. Connect the concentric neutrals to the system ground.
- ❑ Connect the three primary cables to the OPEN PME-3 Switch L/B Bushings.
- ❑ Energize the three primary cables, to the OPEN PME-3 Switch, at the structure where the parallel is to be made.

GENERATOR

- ❑ Turn battery key to the ON position
- ❑ Check the Synchronizing switch in the ON position.
- ❑ Set the Generator Operating Switch to the AUTO position.

- [ ] Set the Generator Breaker to the Auto-Close position by giving the breaker control lever a closed impulse. (GREEN indicator light should be on and RED Flag present on the breaker control switch.)

OPERATION

WARNING: You must first run the unit in the 'test mode' to insure that the phase rotation on the generator side of the breaker, in the ENCORP Switchgear, is the same as the load side phase rotation (non-generator side). Panel mounted phase rotation meters have been installed for visually checking the phase rotation on both sides of the ENCORP breaker. If you feel that the wiring to these meters have been tampered with, use a different means of determining proper phase rotation before running the unit.

> **NOTE:** All switch controls, except for the Standby / Peak Shave switch, are on the 'CUTLER-HAMMER PANELMATE' operator display.

Definitions:

TEST MODE: This mode is to be used to check the phase rotation of the oncoming generator against the load side connection. This mode should be used whenever the generator connections are installed, changed, moved, or anytime you are in doubt.

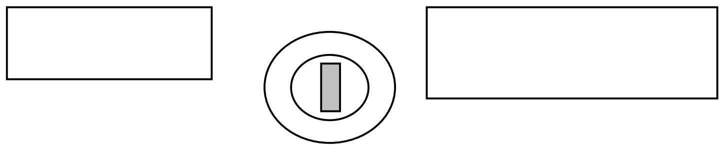
Running the generator in Test Mode will start the generator, close the breaker in the CAT GEN-SET trailer, but will not synchronize or close the generator breaker in the 'Encorp Switchgear'. The Encorp GPC will function as a sync check relay in this mode, but will not actively synchronize the phasing or voltage.

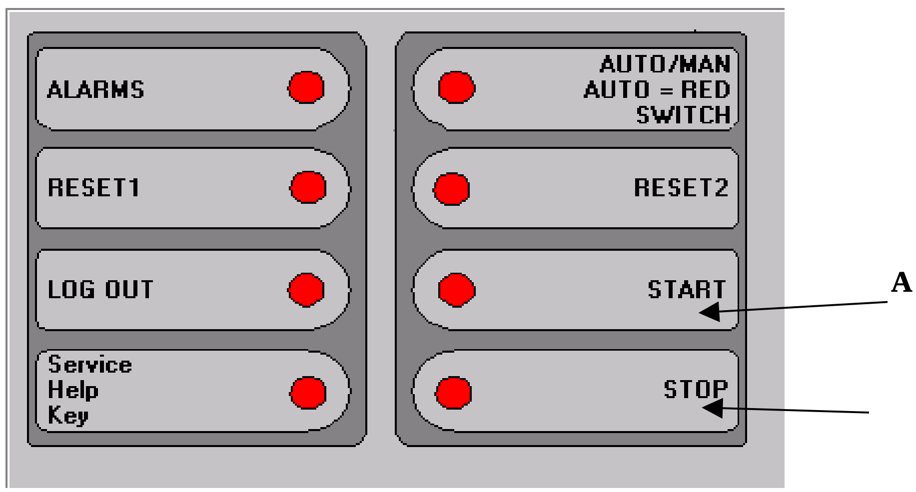
- RUN MODE: **This mode is used to synchronize the generator to the system load and close the Encorp breaker, connecting the generator to the system load or utility.**

Running the generator in Run Mode will start the generator, and depending on the position of the Standby / Peak Shave Switch, will close the generator to a dead bus (Standby) or Synchronize the generator to an energized bus (Parallel) and close the Encorp breaker.

Test Mode:

- Turn the Standby / Peak Shave Key Switch to the PEAK SHAVE position by switching the key to the right.



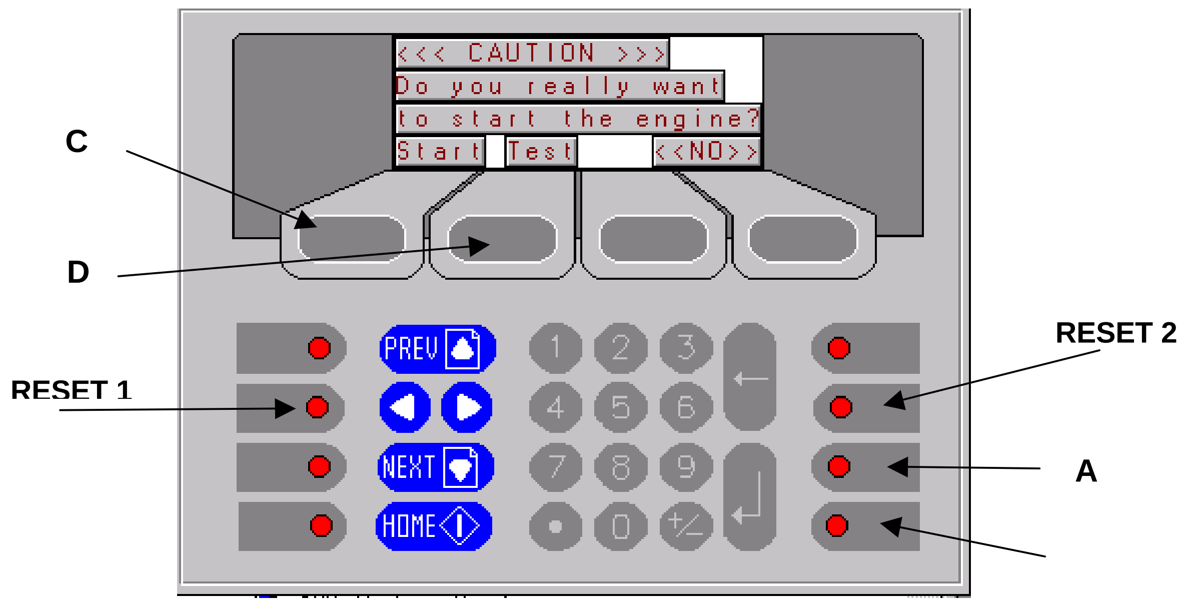


PanelMate

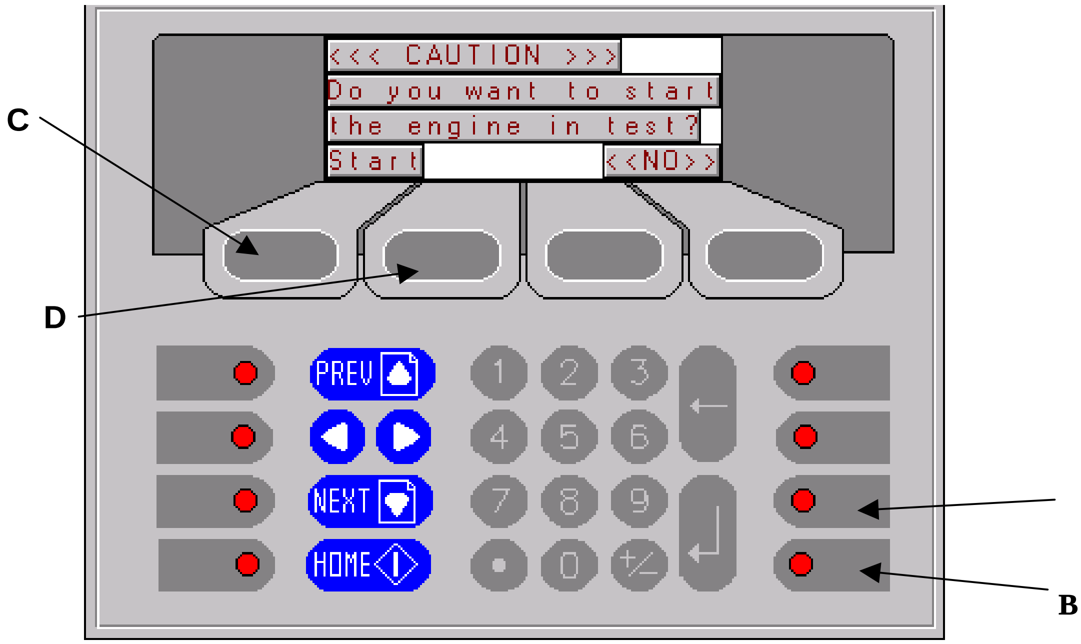
- ❑ Press the Stop Button (B) on the PanelMate

  - ❑ If the Alarm Light is not green, or if you have any doubt that alarms might be present, Press the Alarm button to view the current alarm indications if any. Only after clearing the fault condition that caused the alarm, should you press either of the Reset switches to clear the alarms.

- ❑ Press the start button (A). (This will bring up the following LCD screen)



- Press the Test Button [(D) 2nd button from the left in the row of 4 buttons beneath the LCD display]. (This will bring up the following LCD screen):



PanelMate

- Press the Start Button (C) that this screen brings up (1st button from the left in the row of 4 buttons beneath the LCD display).

  - **CAUTION:** THIS WILL START THE ENGINE. ENSURE THAT IT IS SAFE TO START THE ENGINE/GENERATOR.

  - Check at both phase rotation meters on the face of the ENCORP Switchgear. **CAUTION:** You must always check for proper phase rotation.

  - **Each phase rotation meter should each have a total of four lights on.**

- [ ] On each meter, confirm that all three phase potential lights are on.

- [ ] On each meter, confirm that the same rotation light is lit. Either both lights must indicate “CORRECT” or both lights must indicate :INCORRECT”

NOTE: **If either of these conditions are not met, shut down the generator [press the Stop Button (B)], lock out both the breaker in the ENCORP Switchgear and the Generator trailer, lock out any other sources of power, and correct the phase rotation.**

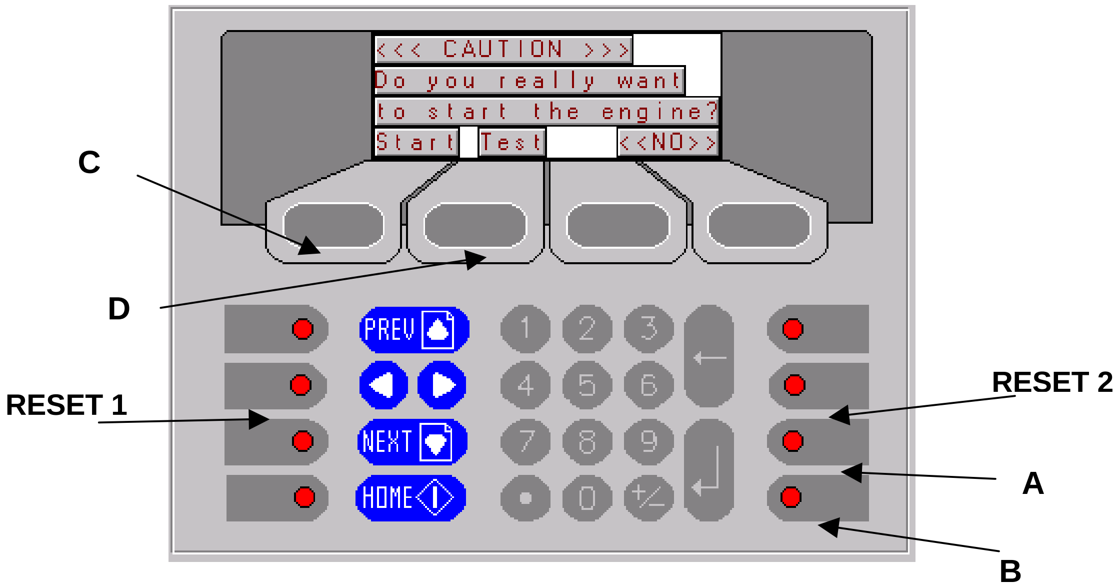
Run Mode:

- [ ] Turn the Standby / Peak Shave Key Switch to the desired position.

- [ ] Press the Stop button (B).

- [ ] If the Alarm Light is not green, or if you have any doubt that alarms might be present, Press the Alarm button to view the current alarm indications if any. Only after clearing the fault condition that caused the alarm, should you press either Alarm Reset switch to clear the alarms.

❑ Press the Start button (A). (This will bring up the following LCD screen).



PanelMate

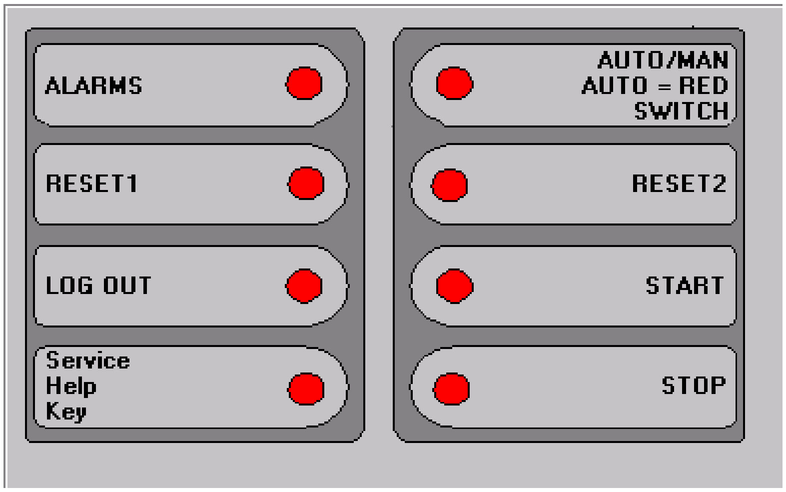
❑ Press the Start Button (C) that this screen brings up (1st button from the left in the row of 4 buttons beneath the LCD display).

- ❑ **CAUTION:** This will start the engine. Ensure that it is safe prior to starting the engine/generator.
- ❑ **NOTE:** To STOP the engine at any time, press the Stop Button (B). This will OPEN the generator breakers and start a "Cooldown Cycle" for the engine.

***In an emergency, the EMERGENCY BREAKER OPEN SWITCH (Red Mushroom Head Button) on the generator breaker can be used to open the breaker and start a cooldown cycle for the engine.

SHUT-DOWN

- ❑ Press the STOP Button on the PanelMate.



PanelMate

  - ❑ This will OPEN the generator breakers and start a “Cooldown Cycle” for the engine.
- ❑ OPEN the PME-3 Switch (AMPS-2) de-energizing the Step-up Transformer and Grounding Bank.
- ❑ Disconnect and **GROUND** the 3 High Voltage Phase leads from the Distribution System
- ❑ Disconnect the 3 High Voltage Phase leads from the PME-3 Switch.
  - ❑ Disconnect the two Generator Control Leads from both CamLock Panels.
  - ❑ Disconnect all the secondary leads from both CamLock Panels.
  - ❑ Disconnect the Ground Leads from the System ground and Step-up Trailer.
  - ❑ Roll and store all the cables in their proper bins.

- [ ] Lock all bins and cabinets.
- [ ] Remove any excess fuel from the generator.
- [ ] Remove generator trailer Jack-Stands and Stair-steps. Store in the back of the generator trailer.
- [ ] Rig all units for transport.

Appendix II

*en*power-GPC Product Datasheet

*en*power™-GPC
PTC Enabled

Highlights
- Embedded PLC software module (IEC 1131-3 Programming Language (Ladder Logic)*
- Communication through LonWorks® *AND* Modbus®* (RS-232/485)
- UL Recognized Component
- Embedded Software modules include Synchronizer, True RMS Real Power Sensor, VAR Sharing, kW Load Sharing Control w/ Soft Loading and Unloading, Base Load Control, VAR/PF Control, Protective Relays and PLC *all in one box*!
- Includes complete Power Metering and Monitoring Functions
- Utility-Grade Device
- Remote operation using a variety of communications methods and our Virtual Power Plant™ software
- Remote Real & Reactive Power Reference Settings
- Programmable, Separately Isolated Switch Inputs and Relay Outputs
- Setup and Configuration with standard PC (No handheld programmer required)

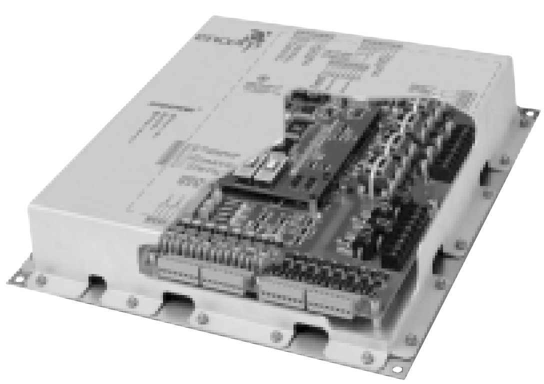
Complete Power Metering & Monitoring Functions
- True RMS real power sensor
- Remote power quality monitoring
- Remote energy/electrical metering
- Remote data logging

Customizable Design for Multiple Applications
- Peak Shaving / Sharing
- Distributed Generation
- Soft loading closed-transition transfer
- Import / export
- Energy management
- Cogeneration
- Genset testing under load
- Real-time pricing
- Interruptible rates

Generator Power Control for Single Genset Applications
The *en*power-GPC with the PTC (Power Transfer Control) Enabled configuration provides safe, reliable transfer of power between a single generator and the utility grid. Standard options include a wide variety of traditional control modules and open-communication protocols integrated into a single unit. This integrated solution creates less headaches with easier and faster installation, increased reliability and the latest cutting-edge technology. Combined with our 2-year standard warranty and 24 hours a day tech support, the *en*power-GPC is the complete solution to your power control needs.

Intuituve Graphical User Interface
- Includes *en*telligent™-NST (Network Service Tool) Setup and Configuration tool for LonWorks® based hardware
- Store parameters for easy transfer between units
- 32-bit application, Windows® 95 and NT® 4.0 compatible
- Runs on standard desktop or laptop PC eliminating the need for a hand-held programmer
- Basic monitoring functions built-in
- Simple "drag-and-drop" interface
- Reads and displays LonMark® object names
- Utilizes simple user-created forms
- Industry standard ODBC compliant database
- High speed OLE automation server
- Reads and displays values and documentation for monitored data points

Protective Relaying Functions
- Sync check (25)
- Auto-synchronizer (25A) w/ voltage matching, two modes available:
  1. Frequency and phase matching
  2. Slip frequency
- Over/under voltage for generator and utility tie (27/59)
- Over/under freq. for generator and utility tie (81 O/U)
- Directional power (32)
- Directional reactive power (32VAR)
- Reverse-phase/phase-balance current (46)
- Phase sequence voltage (47)
- Voltage-restrained overcurrent (51VR)



Specifications

Environmental
Humidity: 95% at 38° C
Temperature: -25°C to 70° C

Power Requirements:
18 to 75 Vdc (<10W)
85-265 Vac (<25W)

Single Phase Potential Input;
60-150 Vac; 50/60 Hz; Delta, Open Delta or Wye Configurations

3-Phase Potential Inputs:
60-150 Vac; 50/60 Hz;Delta, Open Delta or Wye Configurations

Single Phase Current Input:
0-5 Amps; 50/60 Hz

3-phase Current Inputs:
0-5 Amps; 50/60 Hz

Digital Inputs:
20-40 Vac/Vdc; 85-150 Vac/Vdc

Digital Ouputs:
1-120 Vac/Vdc; 0.15 Amps Max

Frequency and Voltage Bias Ouputs:
+/- 3 Vdc and 4-20 mA

Designed to meet or exceed ANSI/IEEE C37.90-1989, IEEE Standards for Relays and Relay Systems Associated with Electrical Power Apparatus (5000 Volt Surge Withstand)

Designed to comply with:
IEC 1000-4-2 Electrostatic Discharge
IEC 1000-4-3 Radiated Immunity
IEC 1000-4-4 Fast Transient
IEC 1000-4-5 Surge Withstand
IEC 1000-4-6 Conducted Immunity
ANSI/IEEE C37.90.1 Surge Withstand/Fast Transient
ANSI/IEEE C37.90.1 Radiated Immunity

Designed for LonMark® Compatibility

Recognized to U.S. and Canadian requirements under the Component Recognition Program of Underwriters Laboratories Inc.

ELECTRICAL

Current (A)	(3) Single phase (A, B, C)	SNVT_amp_f
Votage (V)	(4) Single phase (A, B, C, Aux)	SNVT_volt_f
Frequency (Hz)	(2) Single-phase (A, Aux)	SNVT_freq_f
Voltage Negative Phase Sequence (V)	(1) 3-phase	SNVT_volt_f
Current Negative Phase Sequence (A)	(1) 3-phase	SNVT_amp_f

POWER

Real Power (W)	(3) Single phase (A, B, C)	SNVT_power_f
	(1) 3-phase total	SNVT_power_f
Apparent Power (VA)	(3) Single phase (A, B, C)	SNVT_power_f
	(1) 3-phase total	SNVT_power_f
Reactive Power (VAR)	(3) Single phase (A, B, C)	SNVT_power_f
	(1) 3-phase total	SNVT_power_f
Power Factor	(3) Single phase (A, B, C)	SNVT_pwr_fact_f
	(1) 3-phase average	SNVT_pwr_fact_f

ENERGY

Real Energy (Wh)	(1) 3-phase total	SNVT_elec_whr_f
Apparent Energy (VAh)	(1) 3-phase total	SNVT_elec_whr_f
Reactive Energy (VARh)	(1) 3-phase total	SNVT_elec_whr_f

HARMONICS

Voltage THD	(4) Single phase (A, B, C, Aux)	SNVT_lev_cont_f
Voltage TOHD	(4) Single phase (A, B, C, Aux)	SNVT_lev_cont_f
Voltage TEHD	(4) Single phase (A, B, C, Aux)	SNVT_lev_cont_f
Voltage individual harmonics 2-15	(4) Single phase (A, B, C, Aux)	SNVT _str_int
Current THD	(3) Single phase (A, B, C)	SNVT_lev_cont_f
Current TOHD	(3) Single phase (A, B, C)	SNVT_lev_cont_f
Current TEHD	(3) Single phase (A, B, C)	SNVT_lev_cont_f
Current individual harmonics 2-15	(3) Single phase (A, B, C)	SNVT_str_int

Power demand applications include both instantaneous values and sliding window or thermal demand with programmable intervals and time constants.

Appendix III

SS Interconnection/Generator Test at Metro C&O Center

SS INTERCONNECTION / GENERATOR TEST AT METRO C&O CENTER

DATE: October 26, 1999

I Attendees

Metro C&O	DMS	Orange Cnty	Encorp
Bob Roudebush	Gaspare Vino Ciaravino	Alan Dulgeroff	Doug
Steve Roadinger	Habib Boruah	Bruce Whitaker	
Johnny Soto	Al Figueroa	Israel Lopez	
Bill Yturralde		Lyle Mitchell	
Tom Crogan			
Tom Rege			

II. CONFIGURATION

The SS Encorp / generator setup was connected to a circuit 363 12kv cable pole feed serving padmounted station 363-257 (225kva). The following Figure 1 is a Connection Diagram. A trailer mounted solid-state device with a 3phase switch was connected across the CLF cutouts thereby connecting the generator directly to the end of a 12kV branch feeding Metro C&O Center.

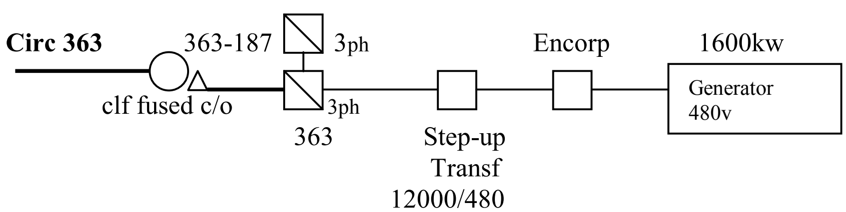


Figure 1.

Voltage & Current Monitoring points:

1) Metro office single phase 120v receptacle that is picked up by the emergency generator in case of an outage.
2) Three phase transformer Stn 363-187 located near the 12kv generator tap.
3) 480v three phase Generator output leads
4) Grounding Bank 12470/480v

III. TESTS

Test #1 Stepup Transformer on B tap- 12,300/480v Synchronize Generator Output 1000kw
Test #2 Step-up Transformer on C tap- 12,000/480v Synchronize Generator Output 500kw
Test #3 Step-up Transformer on A tap- 12,600/480v Synchronize Generator Output 1600kw
Test #4 Step-up Transformer on A tap- 12,600/480v Isolate Metro C&O Center load
Test #5 Step-up Transformer on A tap- 12,600/480v Cold Load Pickup of Metro C&O Center load

IV. TEST RESULTS

Test #1 Synchronize the generator on circuit 363. Step-up transformer B tap setting.

Pre-synchronizing voltage on Circuit 363 was unbalanced at the connection point between the circuit and the generator. (2) Phases were 119v and the third phase was 122v or 2.5%. The voltage at Station F was 122 v on one phase measured on bank 30. The load currents on circ 363 were 2.2, 2.2, 1.5 x 120 or 264, 264, & 180 amps or 32% imbalance between phases at the substation end.

The generator was started in a peakshave mode and was pre-set to synchronize automatically through the Encorp device with an initial generation level of 200 kw. The generation unit control system worked properly and the unit automatically synchronized with the SDGE distribution system. The voltage and current from the generator 480v output leads that connect to the step-up transformer. The generator was operated at 200kw, 500kw, and 1000kw.

At 200kw, 65kw went to the Metro C&O Center and the remaining 135kw backfed into Circuit 363. Generator voltages were 470, 470 & 479 at a .96pf. The imbalance in current and voltage into Circuit 363 remained unchanged by the generator. Voltage in the Metro office increased by 1 volt to 119.

Generator output was then increased to 500kw which increased generator voltages to 482, 489 & 490v at an average 86pf. Stn F reads were 240, 240 & 156 amps and a bus voltage of 122.4 volts. Single phase voltage in the office increased by 1 volt to 120 volts and the three phase voltage increased to 123, 120 & 120 volts.

The generator output was then increased to 1000kw, which required generator voltages of 493. 498 & 500v at a .86pf. Output was 1486, 1286 & 1278 amps. Again, the increase in generated voltage only increased the secondary voltages by another volt. The three phase load went to 122, 122 & 124 volts, while the single phase load in the office area went up by 1 volt to 121 volts.

One of the main purposes of the test was to determine performance of the Encorp solid state device and generator at full output. However because the generator voltage was going to exceed 500v to reach 1600kw output, the Hawthorne technician expressed concern of potential heating. It was decided to change the stepup transformer tap from the B tap to the C tap.

Test #2 Synchronize the generator on circuit 363. Step-up transformer C tap setting.

The tap setting was changed and the Generator was re-synchronized. At 500kw output the generator voltages were 492, 499 & 499 volts at a .92 pf which were substantially higher than at the B tap. It was agreed we needed to go to the full 5% boost tap A to lower the generator voltage.

Test #3 Synchronize the generator on circuit 363. Step-up transformer A tap setting.

The tap was changed to the A tap on the stepup transformer. Three power levels were run at 500kw, 1000kw and 1600kw. An operator error occurred when the generator was restarted after the tap change was made. The generator unit automatically resynchronized itself and generated 500kw without operator intervention. It was subsequently determined when the generator is shut down, the operator must give the control switch an open impulse to prevent autosynchronizing controls from automatically re-synchronizing and reclosing the breaker when the generator is restarted. The proper procedures is to bring the generator output to a minimum and then open the circuit breaker. At 500kw the generator voltages were 470, 476 & 477 at .91pf. which was less generator voltage than in Test #1 at the B tap.

At 1000kw the generator voltages were 480, 486 & 486 at .90 pf. Voltages at the three phase transformer went up to 124, 121 & 121 while the single phase outlet in the Metro office went up 1 volt to 121volts. Stn F bus voltage remained at 122volts and line currents were 240, 216 & 156 amps which are the same as at the B tap. Generator output was then increased to 1600kw resulting in generator voltages of 494, 499 & 499 at a .89pf. Output currents were 2248, 2019 & 2019 amps. Station F voltage was 122 volts and line currents were 228, 216 & 144 amps.

IV. CONCLUSIONS

1. Synchronizing the generator and increasing output in 500kw increments causes only 1 volt increases to secondary loads. However, the method of increasing load through the Encorp device is tedious. A dial-up option should be given to set the amount of increase on the output rather than the step–up option by pushing a button.

2. During the test period, the functionality of the Encorp device during a loss of load condition was not tested because there was no power outage on the circuit the system was tested.

3. Operators were at first uncertain about using the Encorp device to operate the generator, but after training and hands-on operation the ease of operation became evident. Subsequently the operators felt more at ease in using the Encorp device as the control unit. The generator was predominantly operated remotely from the Metro office via a laptop computer as well as a desktop computer from the Distribution Management & Strategies office at Century Park. The remote operation includes monitoring of operational data and stop / start capabilities.

4. There was no significant change in voltage swing noticed on the distribution circuit when the generator was automatically synchronized by the Encorp device.

5. Use of "A" tap on the stepup transformer better compensates for the voltage drop across the step-up transformer and cables and resulted in lower generator voltages at full 1600kw output.

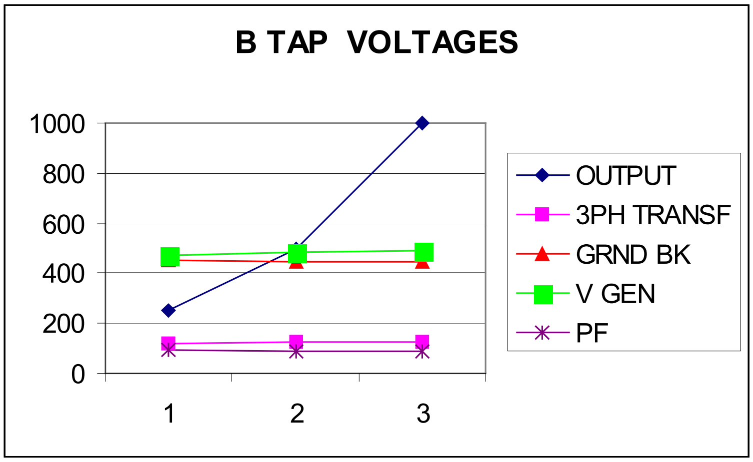
6. Use of the flat tap "B & C" tap's in the stepup transformer cause undesirable high generator voltages at high output levels.

7. Operator did not give the breaker control switch an open impulse when the generator was shut off. When the generator was restarted it automatically re-synchronizing itself and returned to its pre-set output. This needs to be reviewed with the crews and additional steps added to the Electric Standard Practice.

8. A WF4 will need about 1 to 2 hours to make up the trailer connections and get the generator operational.

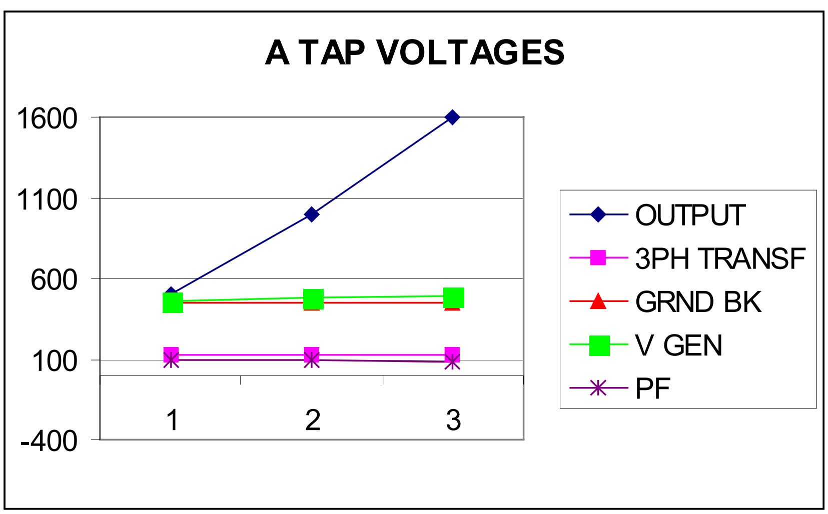
9. Station F Circuit 363 load reduced by 72 amps from 300 amps to 228 amps when the generator produced 1600kw. Substation bank voltage remained unchanged during generator operation.

	B TAP			
OUTPUT	3PH TRANSF	GRND BK	V GEN	PF
250	122	452	470	96.0
500	123	446	482	87.0
1000	124	449	493	86.0

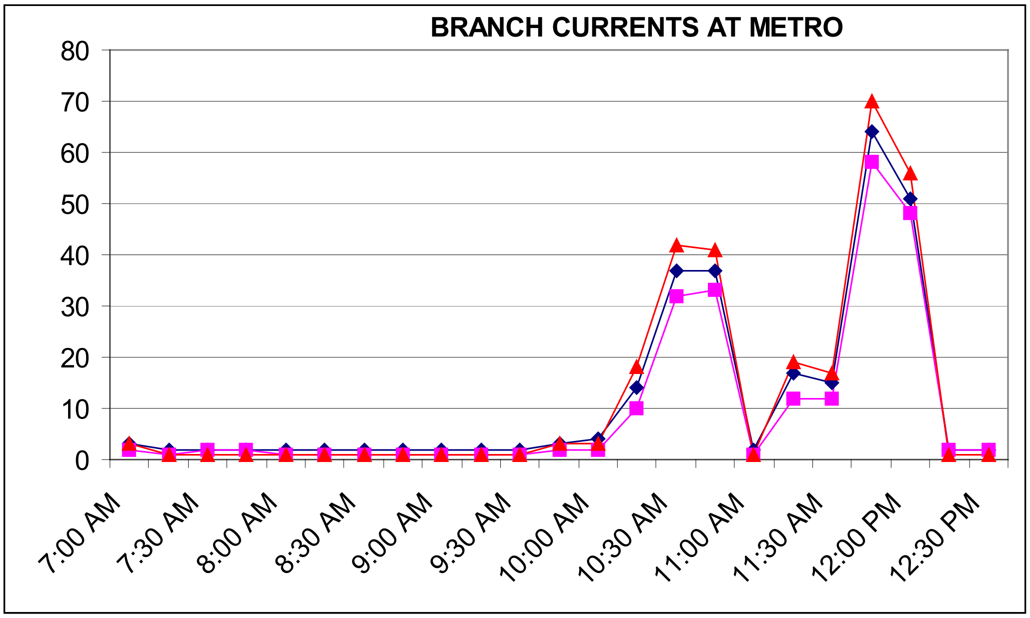


A TAP

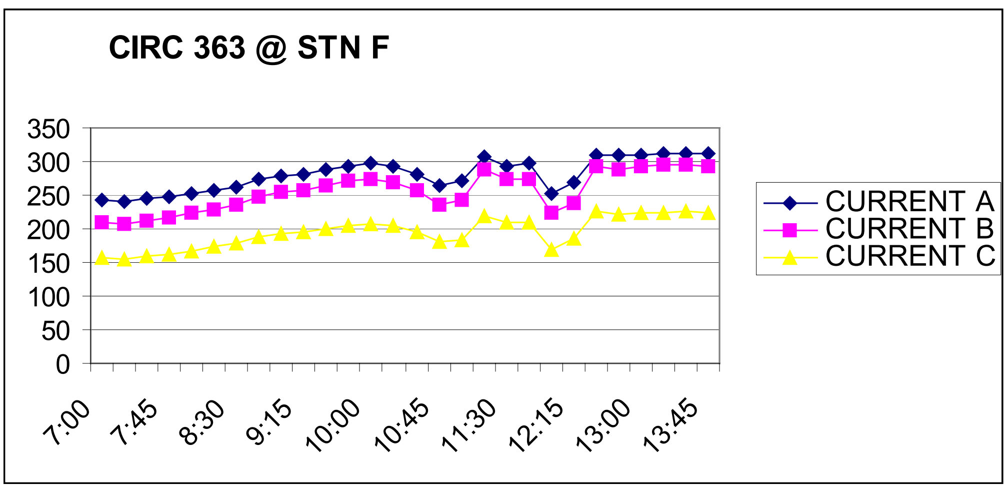
OUTPUT	**3PH TRANSF**	**GRND BK**	**V GEN**	**PF**
500	122	446	463	92.0
1000	124	449	480	90.0
1600	125	453	494	89.0



BRANCH CURRENTS @ METRO C&O



F LINE CURRENTS @ STATION



Appendix IV

SDG&E Standard Practice—Mobile Step-Up Trailer

DIVISION	DEPARTMENT	EFFECTIVE DATE
CUSTOMER OPERATIONS	DISTRIBUTION MGMT. & STRATEGIES	
TITLE		ADDING/REVISING/CANCELING NO. / PAGE
GENERAL PRACTICES	NEW	ALL
SUBJECT		ORIGIONAL DOCUMENT DATE
MOBILE STE-UP TRAILER		MAY 01, 1999

1.0 **PURPOSE**

1.1 This standard practice sets forth safe set-up and working procedures for the operation of the Mobile Step-Up Trailer.

1.2 This trailer is designed for use on 3 ∅ systems only. It cannot be used on a single-phase system.

2.0 **APPLICABILITY**

2.1 This practice applies to all electric construction and maintenance personnel engaged in the set-up and operation of the Mobile Step-Up Trailer.

3.0 **DEFINITIONS**

3.1 **Auto-Synchronization Relay:** A relay attached to the Generator Breaker designed to ensure that the source and load phase sequence is correct and in synchronization before allowing the breaker to close. If the phase rotation is reversed, phasing between the source and load cannot be accomplished and the breaker will not close until the phase rotation has been corrected.

3.2 **Branch Line Island:** Any branch line that is to be isolated from its normal source of feed and has no source for back-feed.

3.3 **Generator,:** Hawthorne Industries, 3∅, 480V, 1750 kVA (max) at 0.80 power factor, mobile Diesel Powered Generator.

3.4 **Generator Breaker:** Utility grade breaker for use on utility distribution systems. This breaker shall include Phase Sequence indication, ground fault trips, current trips, frequency trips, and other features for system protection. This breaker will be used to make parallel with the SDG&E System if appropriate.

3.5 **Grounding Bank:** 300kVA, 12470GRDY/480. Protected by 25A, Bay-o-net type fuses.

3.6 **Ground Fault Relay:** This relay will monitor the distribution system concentric neutral return for a phase to ground fault. Located in the grounding bank, this relay will send a signal to the generator breaker, via a patch cord jumper, opening the breaker when a phase to ground fault occurs.

3.6.1 **Ground Fault Relay Lead:** A #12 AWG insulated cable jumper connecting the Ground Fault Relay to the Generator Breaker thru the Cam-Lock Panels.

ISSUED BY	APPROVED	DATE
GASPARE J. CIARAVINO 'VINO'	VICTOR ROMERO	5/3/00

DIVISION	DEPARTMENT	EFFECTIVE DATE
CUSTOMER OPERATIONS	DISTRIBUTION MGMT. & STRATEGIES	
TITLE		ADDING/REVISING/CANCELING NO. ALL PAGE
GENERAL PRACTICES	NEW	
SUBJECT		ORIGIONAL DOCUMENT DATE
MOBILE STE-UP TRAILER		MAY 01, 1999

3.7 **Grounding Leads, Mobile Step-Up Trailer:** Two (2) grounding leads for grounding the Mobile Step-Up Trailer and the equipment on that trailer. The grounding leads will connect to the system ground at the same facility that the H.V. Cable Leads are to be connected. If the H.V. Cable Leads are to be connected to the Overhead conductors, both ground leads are to be connected to the ground run that is running down that pole. When a system ground or pole ground is not available then drive two (2) ground rods, one in the vacinity of each end of the Mobile Step-Up Trailer, and attach one lead to each of the ground rods.

3.8 **Mobile Step-Up Trailer Schematic:**

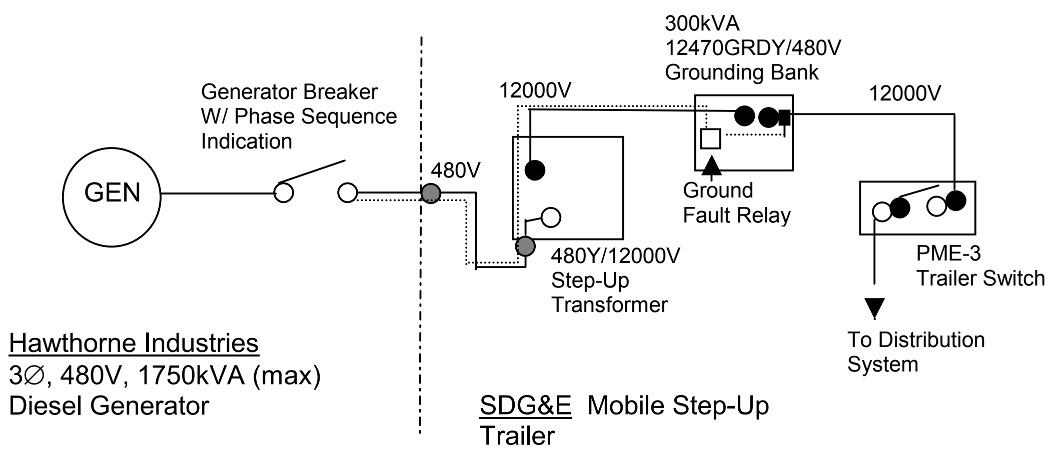


Figure 1, Mobile Power System

3.9 **Mobile Step-Up Trailer:** Step-up power trailer, 480V / 12kV, for supplying power during peak demand and long duration outages.

3.10 **Overhead H.V. Cable Leads:** 100 ft., 15kV, EPR cable leads assembled with L/B Elbows on one end and a stress relief and a hot-line clamp on the other end for connecting to overhead conductors.

3.11 **Phase Rotation Meters:** Meters used to indicate the phase rotation of the source and load applied power. Located on the Generator Breaker Panel, these meters must be installed and operational before the generator can be used with the SDG&E Distribution System.

ISSUED BY	APPROVED	DATE
GASPARE J. CIARAVINO 'VINO'	VICTOR ROMERO	5/3/00

3.12 **PME-3 Trailer Switch:** S&C PME-3 with 200A Load-Breaker Bushing Inserts attached through 600A Extension Bushings. This switch has been installed to prevent ferroresonance conditions when energizing and de-energizing the Temporary Power H.V. Cable Leads. (SP-214) It also provides an isolation point when swapping L/B Elbows to correct phase rotation.

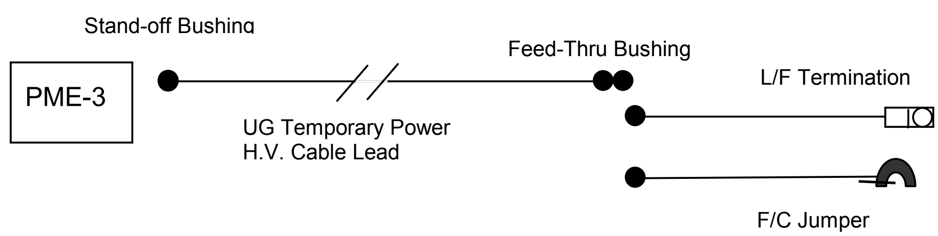
3.13 **Step-up Transformer:** 1500kVA HNB, 12000/480Y. protected by 100A, High Ampere Bay-o-net type fuses. The fuses will be the limiting factor on the transformer loading.

3.14 **Underground H.V. Cable Leads:** 100 ft., 15kV, EPR cable leads assembled with L/B Elbows on both ends.

3.15 **Underground H.V. Cable Lead Jumpers:**

3.15.1 **Live-Front Termination Jumpers:** 15ft Jumpers assembled with L/B Elbows on one end and Live-Front Termination Lugs on the other end. Jumpers are to be used with the Feed-Thru Stand-off Bushings, on the UG H.V. Cable Leads to energize Live-Front equipment. See Figure 2.

3.15.2 **Fuse Cabinet Jumpers:** 15ft Jumpers with L/B Elbows on one end and Hot-Line Clamps on the other end. The jumper elbows are to be plugged into the Feed-Thru Stand-off Bushings on the UG H.V. Cable Leads and jumpered around the Fuse Cabinet, attaching to the Fuse By-pass Jumper Bar, for determining phase rotation only. See Figure 3.



To Be Replace With Photo

Figure 2 & 3 (to be added.)

4.0 **<u>INSTRUCTIONS</u>**

4.1 **Trailer Set-up**

4.1.1 Prior to the trailer set-up, ensure that the generator breaker:

4.1.1.1 Has been labeled “APPROVED FOR SDG&E USE”

4.1.1.2 Has two (2) ‘Phase Rotation Meters’ installed, with one (1) labeled the “SOURCE” and the other labeled “LOAD”, on the breaker.

4.1.1.3 Has a ‘Ground Fault Relay’ connector installed on the Cam-Lock Connector Panel,

NOTE: If any of these items are not present, the generator **CANNOT BE USED**. Immediately call for a new generator that complies with the SDG&E requirements.

4.1.2 The Mobile Generator 'Cam-Lock Panel must be located within 80 feet of the Mobile Step-Up Trailer 'Cam-Lock Panel.

4.1.2.1 This distance will allow adequate slack in the cables for an easy connection.

4.1.3 The Mobile Step-Up Trailer must be located a maximum of 80 feet from the point of the system connection.

4.1.3.1 This distance will allow adequate slack in the cables for an easy connection.

4.1.4 Check open the PME-3 Trailer Switch.

4.1.5 Check each of the Grounding Bank Bay-O-Net fuses for continuity.

4.1.5.1 Replace any open fuses

4.1.6 Check open the Generator 480V. Breaker on the Mobile Generator.

4.1.7 Connect the two-(2) trailer ground leads to the Mobile Step-Up Trailer.

4.1.8 Connect the two-(2) trailer ground leads to the distribution system ground at the structure where the primary H.V. Cable Leads will be connected.

4.1.8.1 If a system ground is not available, drive two ground rods (one at each end of the Mobile Step-Up Trailer) and attach one ground lead to each of the ground rods.

4.1.9 One at a time, connect the 480V power cables to both Cam-Lock panels until all leads are in place. Keep phasing correct. [5 Neutral Leads & 7 Power Leads / Phase, (3 Phases).]

4.1.10 Connect the Ground Fault Relay Lead to both Cam-Lock Panels.

4.1.11 Layout the appropriate "High Voltage (H. V.) Cable Leads" for the Overhead or Underground connections that are to be made. See Section 4.2

4.1.12 Park the three single Stand-off Bushings, with cable leads, in the PME-3 Trailer Switch.

4.1.12.1 Connect the H.V. Cable Lead concentric to the Ground wire in the PME-3 Trailer Switch.

4.1.12.2 Land the H.V. Cable Leads on the PME-3 Trailer Switch L/B Bushings.

NOTE: The Mobile Step-Up Trailer is now ready for system connection.

4.2 **Distribution System Connections.**

4.2.1 **Overhead**

CAUTION: Section 4.1 must be completed before proceeding

4.2.1.1 Pull the Overhead H.V. Cable leads up the pole and hang below the line wire allowing enough cable for an easy connection.

4.2.1.2 Ensure all personnel are in the clear and energize the H.V. Cable Leads to the open PME-3 Trailer Switch.

4.2.1.3 Proceed to Section 4.3.

4.2.2 **Underground**; Connecting to an Open 200Amp L/B Bushing Termination Positions.

CAUTION: Section 4.1 must be completed before proceeding

4.2.2.1 Layout the Underground H.V. Cable Leads to the underground structure where the parallel connection will be made.

4.2.2.2 Ensure that all personnel are in the clear and energize the Underground H.V. Cable Leads via the open L/B Bushing position to the open PME-3 Trailer Switch.

4.2.2.3 Proceed to Section 4.3.

4.2.3 **Underground**; Live-Front Terminations

CAUTION: Section 4.1 must be completed before proceeding

4.2.3.1 Layout the Underground H.V. Cable Leads to the Underground Live Front Equipment where the parallel connection will be made.

4.2.3.2 Connect the live-Front Termination Jumpers into the open position on the Feed-thru Bushing at the end of the Underground H.V. Cable Leads. Connect both neutral concentric wires, on each H.V. Cable Lead, together before proceeding.

4.2.3.3 _Ensure all personnel are in the clear and, using the Distribution Circuit Tester (SP-229), energize the H.V. Cable Leads to the open PME-3 Trailer Switch.

4.2.3.4 Proceed to Section 4.3.

4.2.4 **Underground**; 3∅ Fuse Cabinet (NOT FOR SYSTEM PARALLEL)

CAUTION: Section 4.1 must be completed before proceeding

4.2.4.1 Layout the Underground H.V. Cable Leads to the underground structure where the parallel connection will be made.

4.2.4.2 Connect the Fuse Cabinet Jumpers into the open position on the Feed-thru Bushing at the end of the Underground H.V. Cable Leads. Connect both neutral concentric wires, on each H.V. Cable Lead, together before proceeding.

4.2.4.3 Ensure that all personnel are in the clear and energize the Fuse Cabinet Jumpers and UG H.V. Cable Leads on the Fuse By-Pass Jumper Bar to the open PME-3 Trailer Switch.

IMPORTANT: After the Phase Rotation has been verified correct, OPEN the PME-3 Trailer Switch and then remove the Fuse Cabinet Jumpers before proceeding to Section 4.4.2.3.

4.2.4.4 Proceed to Section 4.3.

4.3 **Connecting the Generator to the Distribution System for parallel operation.**

4.3.1 See sections 4.1 and 4.2 for Set-Up and System Connections prior to proceeding.

4.3.2 Check open the Generator Breaker and start the Diesel Generator.

4.3.3 When the generator reaches normal operating conditions 'CLOSE' the PME-3 Trailer Switch to the open Generator Breaker. (See the Generator Operating Manual for the type of generator being used.)

4.3.4 With the Generator Breaker open, check the phase rotation on both of the Phase Rotation Meters located on the generator breaker panel. The Phase Rotation Meters are to be labeled "SOURCE" and "LOAD".

4.3.5 If phase rotation is correct, proceed to section 4.3.7.

4.3.6 If the source and load phase sequence is opposing;

4.3.6.1 'OPEN' the PME-3 Trailer Switch.

4.3.6.2 Swap any two- (2) L/B Elbows on the PME-3 Trailer Switch.

4.3.6.3 'CLOSE' the PME-3 Trailer Switch.

4.3.6.4 Repeat steps 4.3.3 and 4.3.4.

4.3.7 If the phase sequence is correct, 'operate the 'Auto Synchronization Switch/Button' to close the Generator Breaker.

NOTE: The Generator Breaker will not close until both the generator phasing and the system phasing is in synchronization.

4.3.8 The generator should now be in parallel with the distribution system

4.3.9 If the unit is for load support then no other action is required.

4.3.9.1 Proceed to section 4.5 "Returning the Distribution System To Normal"

4.4 **Supplying Generated Power to Branch Line Islands.**

NOTE: Prior to proceeding, check the phase rotation at any 3∅ customer panel and record that reading. This is important so that the proper phase rotation can be verified when the normal system power has been re-energized.

4.4.1 **Parallel Operation Prior to Branch Line Island Separation**.

NOTE: This procedure is to be used when an outage is not desirable when connecting the generator to the system Branch Line Island and a 3∅ Gang Operated Switch is available for breaking the system power.

4.4.1.1 See sections 4.1 and 4.2 for Set-Up and System Connections.

4.4.1.2 To parallel the generator with the distribution branch line see section 4.3.

4.4.2 **Supplying Power With a Momentary Outage**

NOTE: This procedure is to be used when:

- An outage must be taken before connecting the generator to the system Branch Line Island.
- An outage would be more practical when connecting the generator to the system Branch Line Island.
- This includes branch line islands where a 3∅ Gang Operated Switch <u>is not available</u> to open the distribution system feed.

4.4.2.1 See sections 4.1 and 4.2 for Set-Up and System Connections.

4.4.2.2 Connecting to the Overhead, Underground with 200Amp L/B Bushing Termination positions or Live-Front Terminations.

4.4.2.2.1 Check open the Generator Breaker and start the Diesel Generator.

4.4.2.2.2 When the generator reaches normal operating conditions 'CLOSE' the PME-3 Trailer Switch to the open Generator Breaker. (See the Generator Operating Manual for the type of generator being used.)

4.4.2.2.3 With the Generator Breaker open, check the phase rotation on both of the Phase Rotation Meters located on the generator breaker panel.

4.4.2.2.4 If the phase rotation is correct, 'OPEN' the PME-3 Trailer Switch, and proceed to section 4.4.2.2.6.

4.4.2.2.5 If the source and load phase sequence is opposing;

4.4.2.2.5.1 'OPEN' the PME-3 Trailer Switch.

4.4.2.2.5.2 Swap any two- (2) L/B Elbows on the PME-3 Trailer Switch.

4.4.2.2.5.3 'CLOSE' the PME-3 Trailer Switch.

4.4.2.2.5.4 Repeat steps 4.4.2.2.3 and 4.4.2.2.4.

4.4.2.2.6 Isolate the Branch Line Island via a 3∅ Switch, L/B Elbows, or Cutouts.

NOTE: For Live-Front Terminations use the Distribution Circuit Tester (SP-229) to isolate the normal system Feed.

NOTE: For opening Cutouts use the Loadbuster Tool (SP-117) to break drop load.

4.4.2.2.7 'CLOSE' the PME-3 Trailer Switch.

4.4.2.2.8 'CLOSE' the Generator Breaker energizing the Branch Line Island.

4.4.2.2.9 Verify the proper phase rotation on the same 3∅ customer panel that the original phase rotation was first checked.

4.4.2.3 **Underground**, 3∅ Fuse Cabinet.

NOTE: Ensure that the PME-3 Trailer Switch has been opened and the Fuse Cabinet Jumpers have been remove from the Fuse Cabinet before proceeding. See section 4.2.4, System Connection to an Underground 3∅ Fuse Cabinet

4.4.2.3.1 Remove the Load side L/B Elbows from the Fuse Cabinet and plug into the associated Feed-Thru Bushings on the Underground H.V. Cable Leads.

4.4.2.3.2 When all Load side L/B Elbows have been installed on the Feed-Thru Bushings;

4.4.2.3.2.1 'CLOSE' the PME-3 Trailer Switch.

4.4.2.3.2.2 'CLOSE' the Generator Breaker energizing the Branch Line Island.

4.4.2.3.3 Verify the proper phase rotation on the same 3∅ customer panel that the original phase rotation was first checked.

4.5 **Returning The Distribution System To Normal**

4.5.1 **Breaking Parallel**

4.5.1.1 ‘OPEN’ the PME-3 Trailer Switch separating the generator from the distribution system.

4.5.1.2 ‘OPEN’ the Generator Breaker and shutdown Generator.

4.5.1.3 De-energize the H.V. Cable Leads to the open PME-3 Trailer Switch.

4.5.1.4 For trailer storage go to section 4.6.

4.5.2 **Separating the Generator from the Branch Line Island with a Momentary Outage**

NOTE: The following steps are based on the assumption that the phasing was verified on the old cable and the new cable was made-up keeping the phasing correct.

4.5.2.1 Overhead Taps and Underground with 200Amp L/B Termination positions or Live-Front Terminations.

4.5.2.1.1 ‘OPEN’ the PME-3 Trailer Switch separating the generator from the distribution system.

4.5.2.1.2 ‘CLOSE’ in the distribution system power via a 3∅ Switch, L/B Elbows, Cutouts, or Switch.

NOTE: For Live-Front Terminations use the Distribution Circuit Tester (SP-229) to energize the distribution system branch line.

4.5.2.1.3 Verify the proper phase rotation on the same 3∅ customer panel that the original phase rotation was first checked.

4.5.2.1.4 ‘OPEN’ the Generator Breaker and shutdown Generator.

4.5.2.1.5 De-energize the H.V. Cable Leads to the open PME-3 Trailer Switch.

NOTE: For Live-Front Terminations use the Distribution Circuit Tester (SP-229) to isolate the H.V. Cable Leads.

4.5.2.1.6 For trailer storage go to section 4.6.

4.5.2.2 **Underground**, 3∅ Fuse Cabinet.

4.5.2.2.1 ‘OPEN’ the PME-3 Trailer Switch de-energizing the H.V. Cable Leads and the underground Branch Line Island.

4.5.2.2.2 Remove the Fuse Cabinet L/B Elbows from the Feed-Thru Bushings, in the Fuse Cabinet, and plug them into the open Fuse Cabinet Bushings re-energizing the branch line.

4.5.2.2.3 Verify the proper phase rotation on the same 3∅ customer panel that the original phase rotation was first checked.

4.5.2.2.4 ‘OPEN’ the Generator Breaker and shutdown Generator.

4.5.2.2.5 For trailer storage go to section 4.6.

4.5.2.3 If phasing is correct, proceed to section 4.6.

4.5.2.4 If phasing is reversed

4.5.2.4.1 Swap any two (2) phases where the new wire was connected to the branch line.

4.5.2.4.2 Verify the proper phase rotation on the same 3∅ customer panel that the original phase rotation was first checked.

4.5.2.4.3 If phasing is correct, proceed to section 4.6.

4.6 **Generator Trailer and Mobile Step-Up Trailer Stora**ge

4.6.1 Disconnect the Temporary Power H.V. Cables from the PME-3 Trailer Switch, roll up and store cables.

4.6.2 Disconnect the Ground Fault Relay Lead from Cam-Lock Panels and store the lead.

4.6.3 Disconnect the 480V. Cables from both Cam-lock Panels, roll up and store cables.

4.6.4 Disconnect the Trailer Grounds and store

4.6.5 If ground rods were used, remove the ground rods and store.

4.6.5.1 If the trailers are being stored over night, cover the ground rod to prevent pedestrian injury

4.6.6 Lock all cabinets and bins.

4.6.7 Rig both trailers for over night or for travel.

5.0 **REFERENCES**

5.1 Employee Safety Handbook

5.2 Electric Standard Practice 229; Distribution Circuit Tester

5.3 Electric Standard Practice 117, Loadbuster Tool

6.0 **ATTACHMENTS**

6.1 Photos

6.2 Checklists